ANALYSIS OF WDMET M26 GRENADE CASES FOR ARMOR VEST PROTECTIVE EFFECT

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Aberdeen Proving Ground, Maryland

June 1975

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER EB-TR-75042	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD-A010 311
4. TITLE (and Subtitle) ANALYSIS OF WDMET M26 GRENADE CASES FOR ARMOR VEST PROTECTIVE EFFECT		5. TYPE OF REPORT & PERIOD COVERED Technical Report September 1973 to October 1973 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John W. Jameson Jules M. Merkler Myra C. Cohn		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander, Edgewood Arsenal Attn: SAREA-BL-BS Aberdeen Proving Ground, Maryland 21010		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS See Item 18
11. CONTROLLING OFFICE NAME AND ADDRESS Commander, Edgewood Arsenal Attn: SAREA-TS-R Aberdeen Proving Ground, Maryland 21010		12. REPORT DATE June 1975 13. NUMBER OF PAGES 11 10
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Project Numbers (Analysis):	1W562607AD1701	1W562603A00302	1W562607AD1403
	1W562603A00406	1W062116A08103	1W564602D02802
(Publication):	1X562603A31200	1W062116A09200	
1W662604AH97	1W662708A01101	1W562607AD1201	

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Armor	Grenade fragments	Vest
Armor vest	M26 grenade	WDMET
Body armor	Protection	Wounds
Fragments	Thorax	
Grenade	Thorax wounds	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A statistical analysis is presented of 300 WDMET cases where wounds resulted from M26 grenades and where it was definitely known whether or not an armor vest was worn. Statistical methods employed are principally chi square tests. Data indicate that (1) an armor vest reduces the proportion of wounds to the thorax versus wounds to other body parts; (2) it is doubtful whether the vest reduces the proportion of men having thorax wounds versus men having wounds only to other body parts; and (3) the Marine vest offers more protection than the Army vest.

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PREFACE

The work described in this report was authorized under Project numbers: 1W562607AD1701, 1W562603-A00406, 1X562603A31200, 1W662708A01101, 1W562603A00302, 1W062116A08103, 1W062116A09200, 1W562607AD1201, 1W562607AD1403, and 1W564602D02802. This work was started in September 1973 and completed in October 1973.

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I. INTRODUCTION.

The analysis presented below was an offshoot of a data base which was extracted from Wound Data Munitions Effectiveness Teams (WDMET) records in order to develop a *multiple-injury incapacitation* model for the M26 (2-grain fragment) grenade. It therefore does not go deeply into interpretation of findings but rather gives a statistical evaluation, where sample size permits, of observations drawn from this data base.

The comments and conclusions given are subject to the criteria listed at the beginning of the analysis and pertain only to the specific M26 data base mentioned above. The conclusions drawn must be viewed with caution because it is doubtful that the cases available for study are a random sample in the statistical sense.

The Army and Marine WDMET teams gathered data in the field in Vietnam for 2 years, from July 1967 through June 1969.

The standard Army and Marine armor vests in the Vietnam conflict were:

Army: Armor, Body, Fragmentation Protective, M1952.

Marine: Armor, Body, Fragmentation Protective, Upper Torso, M1955.

II. ANALYSIS AND DISCUSSION.

The following analysis is based on 300 WDMET cases which met the following criteria:

1. Wounds resulted from M26 grenades.
2. Man received at least one wound.
3. In multiple wound cases, wound counts were available for the thorax and for the whole body.
4. It was definitely known whether the man was or was not wearing an armor vest.

In all but three of the 300 cases, an estimate of the hit range was available.

The work "wound" in this discussion means any wound whether serious or trivial. In particular, the term "thorax wound" includes not only wounds penetrating into the thoracic cavity but also any other wound, however superficial, to the thoracic region of the body.

Table 1 shows the total number of thoracic and nonthoracic wounds for armored and unarmored men.

Table 1. Wound Counts

Protection	Total number of thoracic wounds	Total number of nonthoracic wounds	Totals
Armored	89	1239	1328
Unarmored	232	1624	1856
Totals	321	2863	3184

Thus, among the armored men, 6.7% of the wounds were thoracic; among the unarmored men, 12.5% of the wounds were thoracic. The chi square statistic for this 2 X 2 contingency table is 28.07 with 1 degree of freedom. Under a null hypothesis that the expected ratio of thoracic to nonthoracic wounds is the same whether a man wears a vest or not, the probability of such a chi square occurring by chance is less than 0.001, so the data strongly indicate that the vest is in fact reducing the number of thoracic wounds. Chi squares for this and other 2 X 2 contingency tables in this report were calculated by the method of Formula 7.27.[1]

There were 100 armored and 200 unarmored men. Thus, from table 1, the mean number of wounds per man was 13.3 for armored and 9.3 for unarmored men. A chi square test (of a slightly different type) was done to determine whether the total wound counts for the two groups of men are significantly different, and this chi square value is 100.5 for 1 degree of freedom, leaving little doubt that there is a difference between the groups. This chi square was calculated by the method of paragraph 9-1.2.[2] Examination of the range figures shows that the mean range for 99 armored men was 4.5 meters and the mean range for 198 unarmored men was 8.7 meters. This is consistent with the difference in mean wound numbers but we have no explanation for the curious circumstance that the armored men tended to have been struck from a closer range.

In view of this circumstance, it is of interest to inspect the wound counts by range as shown in table 2.

Table 2. Wound Counts by Range

Range, meters	Unarmored			Armored		
	Total wounds	Thorax wounds	Distribution to thorax	Total wounds	Thorax wounds	Distribution to thorax
			%			%
0 - 1	817	113	13.8	760	42	5.5
1 - 2	334	43	12.8	179	11	6.1
2 - 4	187	17	9.1	156	11	7.1
4 - 8	296	49	16.6	76	6	7.9
8 - 16	104	2	1.9	82	6	7.3
16 - 32	91	4	4.4	1	0	0.0
>32	8	2	25.0	0	0	–
Subtotal	1837	230	–	1254	76	
Unknown	19	2	10.5	74	13	17.6
Totals	1856	232	–	1328	89	

In table 2 we see that among armored men thorax wounds are a smaller percentage of total wounds except in the range 8 to 16 meters and in the "unknown" range.

[1] Ostle, B. Statistics in Research. Iowa University Press, Ames, Iowa. 1963.

[2] Natrella, M. Experimental Statistics, Section 2, Analysis of Enumerative and Classificatory Data. Ordnance Corps Pamphlet ORDP 20-111. US Government Publication (Army Ordnance Corps). 1962.

We can also calculate chi squares for each range in table 2 except for ranges 16 to 32 and over 32, where the numbers of wounds in armored men are insufficient for the test. The reversals at 8 to 16 meters and "unknown" are not significant (probability greater than 0.1); the only significant chi squares are at 0 to 1 and 1 to 2 meters (probability less than 0.05).

The next question to consider is whether the vest reduces not only the number of thorax wounds but also the number of men receiving thorax wounds. For all 300 men, the figures are shown in table 3.

Table 3. Thoracic and Nonthoracic Casualties

Protection	Number of men with thorax wounds	Number of men without thorax wounds	Totals
Armored	27	73	100
Unarmored	69	131	200
Totals	96	204	300

Chi square for this 2 X 2 contingency table (3) is only 1.4, and the probability of this occurring by chance is greater than 0.2. The proportion of men having thoracic wounds is lower among armored men (27% versus 34.5% for unarmored men), but we cannot say that the difference is statistically significant.

Some interesting comparisons can be made between the Army and Marines in regard to wearing of the vest and the differing effectiveness of the two vests in preventing thoracic wounds. Among these WDMET M26 cases, a much higher proportion of marines wore the vest than Army soldiers (table 4).

Table 4. Numbers of Men Wearing and Not Wearing the Vest Among Army and Marine M26 WDMET Cases

Service	Armored	Unarmored	Totals
Army	15	186	201
Marines	85	14	99
Totals	100	200	300

The interservice contrast is so strong that it hardly needs chi square (179.9) to sharpen it. One implication is that table 1 above, indicating reduction of thorax wounds among armored men, reflects principally the effect of the Marine vest.

There were no armored Army men at a range of 1 to 2 meters, and only one wearing armor at ranges greater than 16 meters. By pooling all the data for ranges (0 to 1, 2 to 4, 4 to 8, 8 to 16 meters) in which both soldiers and marines wearing the vest were found, we obtained the figures shown in table 5.

Table 5. Wound Counts for M26 WDMET Cases Wearing the Vest at Ranges 0-1, 2-4, 4-8, and 8-16 Meters

Service	Number of thoracic wounds	Number of nonthoracic wounds	Totals
Army	36	212	248
Marines	25	772	797
Totals	61	984	1045

Chi square for the data in table 5 is 42.51 (probability less than 0.001) and the indication is that the Army vest was less effective in preventing thoracic wounds.

Table 6 indicates that the explanation is not to be found in difference of range.

Table 6. Numbers of Armored Men at Various Ranges Among M26 WDMET Cases

Range, meters	Army	Marines
0 - 1	4	25
2 - 4	3	17
4 - 8	3	13
8 - 16	5	15

In table 6, the mean range for Army cases is 5.9 meters and for Marine cases, 4.6 meters. Various explanations may be proposed for the contrast in table 5; for example, the Marine vest is 50% heavier and has higher ballistic limits; or perhaps the marines more often wore the vest closed in front. Table 7 gives the range-by-range breakdown.

Table 7. Wound Counts for M26 WDMET Cases Wearing the Vest, Range-by-Range

Range, meters	Service	Number of thorax wounds	Number of nonthorax wounds	Chi square
0 - 1	Army	20	112	
	Marine	5	520	54.28
2 - 4	Army	3	30	0.02
	Marine	8	115	
4 - 8	Army	0	5	Insufficient
	Marine	6	65	data
8 - 16	Army	13	65	2.16
	Marine	6	72	

Thus the better performance of the Marine vest is most striking at the closest range, but it is also better percentage wise at ranges of 2 to 4 and 8 to 16 meters.

One way to test the hypothesis that the Marine vest appears to be better because the marines were more likely to close the vest would be to examine data on only those armored men who had posterior wounds. Unfortunately, there is only one Army M26 case of an armored man where impact is known to be posterior, so the data are insufficient for such a test.

III. CONCLUDING REMARKS.

Before conclusions are stated, a caution must be given. Sampling is said to be random when every member of the population under study has an equal chance for inclusion in the sample. This study necessarily considers only the 300 available cases and it may be doubted that they are a random sample of all episodes in which US Marines or US Army soldiers received M26 grenade wounds in Vietnam. Perfect random sampling is hard to achieve even under ideal peacetime conditions. But the statements of probability and significance in the foregoing analysis could not be made without the assumption of random sampling.

The numbers in tables 1 through 7 could have been presented without interpretation; it adds interest, however, to point out which ratios are highly unlikely under random sampling and a typical null hypothesis like that stated for table 1.

We therefore say: if the 300 WDMET cases considered were a random sample, then the following conclusions could be drawn:

1. An armor vest reduces the proportion of M26 grenade fragment wounds to the thorax versus those to other body parts.

2. It is doubtful that the vest reduces the proportion of men having such grenade fragment wounds to the thorax versus men having such wounds only to other body parts.

3. The Marine vest offers more protection than the Army vest against M26 grenade fragment wounds to the thoracic region of the body.

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